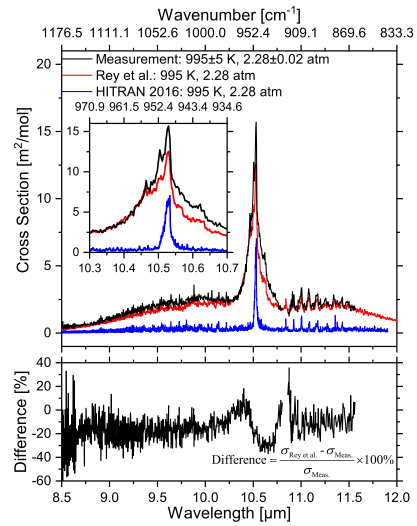
A NEW STRATEGY FOR COLLECTION OF HIGH-TEMPERATURE BROAD-BAND ABSORPTION SPECTRA FOR GAS-PHASE MOLECULES IN THE MID-INFRARED

YIMING DING, CHRISTOPHER L STRAND, SARAH E JOHNSON, RONALD K HANSON, *Mechanical Engineering, Stanford University, Stanford, CA, USA.*

To address the notable lack of knowledge on high-temperature absorption cross sections of important molecular species in combustion and exoplanets, a new strategy is proposed and deployed to collect broad-band absorption spectra in shock-heated gases. The methodology utilizes a broad-scan, rapid-tuning external-cavity quantum cascade laser in conjunction with a shock tube and is capable of providing quantitative spectroscopic information across full vibrational bands spanning over 200 cm^{-1}within 6 ms ($>$ 30,000 cm^{-1}/s), with a spectral resolution between 0.3 – 0.6 cm^{-1}. This experimental approach is demonstrated with absorption spectra measurements on the ν_7 vibrational band of ethylene ($\mathrm{C_2H_4}$) from 8.4 μm to 11.7 μm at temperature/pressure conditions between 800 – 1600 K, 1 – 5 atm. The measured spectra are compared against spectral simulations using existing spectroscopic databases, showing better agreement with the line list of Rey et al.[a] than of HITRAN 2016[b]. With the current set of instruments available, this methodology could be applied to numerous gas-phase molecules that have attractive absorption features in the spectral range of 3.6 – 11.7 μm and opens an efficient pathway towards improving knowledge on radiation absorption in the mid-infrared at high temperatures.



[a]M. Rey, T. Delahaye, A. V. Nikitin, and V. G. Tyuterev, “First theoretical global line lists of ethylene ($^{12}\mathrm{C_2H_4}$) spectra for the temperature range 50-700 K in the far-infrared for quantification of absorption and emission in planetary atmospheres,” Astron. Astrophys., vol. 594, pp. 1–16, 2016.

[b]I. E. Gordon et al., “The HITRAN2016 molecular spectroscopic database,” J. Quant. Spectrosc. Radiat. Transf., vol. 203, pp. 3–69, 2017.